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Bioconversion of *Tithonia diversifolia* (Mexican Sunflower) and Poultry Droppings for Energy Generation: Optimization, Mass and Energy Balances, and Economic Benefits

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Abstract

Anaerobic co-digestion of pretreated and untreated samples of *Tithonia diversifolia* with poultry droppings was carried out to establish a permanent solution to the menace of this stubborn weed present in crops worldwide. The physicochemical and microbial characteristics of the substrates (*T. diversifolia*, poultry droppings, and rumen contents) were evaluated using standard methods. The initial high chemical oxygen demand (COD) values were significantly reduced by 60.45 and 56.33% after digestion. In all the experiments, biogas production was progressive until between the 16th and 21st days in most cases, after which a decrease was observed until the end of the experiments. The most desirable actual/experimental biogas yields from both experiments were 2984.20 and 1408.02 m^3/kg total solids (TS) fed, with desirability of 100% for both experiments. Gas chromatographic analysis revealed the CH_4 and CO_2 contents of both experiments to be 67 ± 1.5%; 22 ± 2% and 60 ± 1%; 23 ± 2%, respectively. The response surface methodology (RSM) model and the artificial neural networks (ANNs) model were employed in data optimization, and the optimal values for each of the five major parameters optimized are as follows: temperature

(*A*) = 37.20 °C, pH (*B*) = 7.50, retention time (*C*) = 27.95 days, total solids (*D*) = 11.97 g/kg, and volatile solids (*E*) = 8.50 g/kg. The root-mean-square error of biogas for RSM (105.61) was much higher than that for ANNs (84.65). In the pretreated experiment, the most desirable predicted yield for RSM model was 3111.07 m^3/kg TS fed, while that of ANNs model was 3058.50 m^3/kg TS fed; for the experiment without pretreatment, it was 1417.39 and 1412.50 m^3/kg TS fed, respectively. In all, there was a 54.44% increase in predicted biogas yield in the experiment with pretreatment over the untreated. Based on the coefficient of determination (R^2), the mean error, and predicted biogas yields, the ANNs model was found to be more accurate than RSM in the study. The energy balance revealed a positive net energy which adequately compensated for the thermal and electrical energies used in carrying out thermo-alkaline pretreatment. The co-digestion of these substrates for bioenergy generation is hereby advocated.